APPENDIX C: CENTENNIAL ENGINEERING TRAFFIC CAPACITY STUDY

Traffic Capacity Study US-189, Wildwood to Deer Creek State Park

DEPARTMENT OF TRANSPORTATION

UTAH

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CENTENNIAL

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INTRODUCTION

This report is the result of a traffic impact analysis of future traffic on U.S. 189 as it relates to the proposed redesign/reconstruction of the road through Provo Canyon from Wildwood to Deer Creek State Park. The report has the following purposes:

1. To describe the various alignment alternatives under consideration by the Utah Department of Transportation (UDOT), and to explain why each alternative is being considered;

2. To determine a design hour traffic volume for the design year of 2015;

3. To determine the design year operational level of service for each alignment alternative;

4. To make recommendations for improvements to U.S. 189, Wildwood to Deer Creek State Park, in order to improve the operational level of service to acceptable levels in the design year.

To achieve the foregoing, the factors affecting the capacity of a roadway need to be evaluated. Among the most important factors are: design traffic volumes; the number of lanes; lane and shoulder width; and roadway grade. These factors will be determined for each alternative and used to calculate the expected operational level of service.

In Section 1, the existing and proposed roadway alignments will be briefly described in terms of the geometric factors affecting capacity. In Section 2, the traffic count data assembled for this report will be discussed. In Section 3, the methodology used to project the design hour volumes will be discussed fully. And in Section 4, the information described in Sections 1 - 3 will be used to perform a capacity analysis using the methodology developed by the Transportation Research Board for the 1985 Highway Capacity Manual. The findings and recommendations of this study are summarized in Section 5.

1. ALIGNMENT ALTERNATIVES

The project begins near the Wasatch County line and ends near the entrance of Deer Creek State Park. The existing highway in the project area is a two lane facility with 12' travel lanes and minimal paved shoulders. Posted speed limit within the project area is 50 MPH, with several reduced speed curves. Passing lanes are available in two locations for up canyon traffic and one location for down canyon traffic. Each of these passing lanes are approximately .2 miles in length.

The SEIS preferred alternative is a four lane facility intended to provide both mobility and accessibility for motorists. The highway design criteria will accommodate an 80

KPH (50 MPH) design speed, 3.6 meter (12') traffic lanes, acceleration and deceleration lanes for right turns, center left turn lanes, a paved .6 meter (2') wide inside shoulder and 2.4 meter (8') wide outside shoulder, a 3 meter (10') wide median with vegetation, 3 meter (10') wide clear zone with guardrail or 6.7 meter (22') without guardrail.

The alignment will closely follow the existing alignment except for two diversions that will eliminate the reduced speed curves. One is at the horseshoe bend curve near canyon meadows, and another at the Deer Creek dam where the alignment will cross the river valley with a bridge structure downstream of the dam and tie back into the existing alignment near the south abutment.

Two additional alternatives were evaluated with respect to traffic capacity. Both would be a three lane facility that would closely follow the existing highway. One alternative would have two lanes up canyon and one lane down canyon. The other would have two lanes down canyon and one lane up canyon. Both alternative alignments would meet current design criteria in terms of travel lane width, shoulder width, clear zone and grade.

2. EXISTING AND HISTORICAL TRAFFIC VOLUMES

Three sources were utilized for traffic data for this study: the UDOT permanent traffic count station located in the canyon; traffic counts collected for the Supplemental Environmental Impact Statement (SEIS); and traffic counts collected by Centennial under the direction of UDOT in May 1994.

2.1. UDOT Permanent Count Station Data

The primary source of traffic count data for U.S. 189 through Provo Canyon is the permanent count station installed and maintained by UDOT at mile post (M.P.) 13.42. The count station collects traffic counts 24 hours per day, 365 days per year. Traffic volumes are counted separately in the northbound and southbound directions. The count station is unable to determine vehicle classification. Classification describes vehicles by type, i.e., passenger cars, trucks, recreational vehicles (RV's) and buses.

From the detailed data collected at the permanent count station, the annual average daily traffic (AADT) can be calculated. The daily traffic volumes for each calendar year are averaged to obtain the AADT for the year. The AADT for the years 1975 through 1993 are shown in Table 2.1.1.

Table 2.1.1. Average Annual Daily Traffic, 1975 - 1993

Year	Annual Average Daily Traffic	Year	Annual Average Daily Traffic
1975	4290	1985	5660
1976	4610	1986	5780
1977	4690	1987	6150
1978	5370	1988	6480
1979	5170	1989	6642
1980	5150	1990	6947
1981	5410	1991	7188
1982	5580	1992	7772
1983	5770	1993	8173
1984	5710		

In Section 3, Design Hour Traffic Volumes, the data in Table 2.1.1 will be used to help determine the design year and design hour traffic volumes.

2.2. Data Collected for the Supplemental Environmental Impact Statement

Counts were collected for the Supplemental Environmental Impact Statement (SEIS). The SEIS was approved in November 1989. Counts were collected at several locations in the canyon and include volumes and classification in both the northbound and southbound directions. Summaries of this data are shown in the SEIS, however, the complete data set and specific documentation regarding the method of collection were unavailable. Additionally, all of the data collected for the SEIS is at least five years old and may not represent current conditions.

2.3. Data Collected by Centennial

It is standard practice when planning for a highway design to choose an hourly traffic volume from among the 100 highest hours expected in the design year. The complete UDOT permanent count station data set for 1990, 1991, 1992 and 1993 was used to determine which hours to count. For each of those years, one or more of the year's highest 100 hourly traffic volumes occurred between 11:00 AM and 7:00 PM on the Monday following the Memorial Day weekend. Counts were collected in the canyon by Centennial under the supervision of UDOT from 11:00 AM to 7:00 PM on Monday, May 30, 1994, (the Monday following the Memorial Day weekend). The counts were collected at a location just north of the Wildwood/Sundance turnoff and include volumes and classification in both the northbound and southbound directions. Table 2.3.1 shows hourly summaries of the counts.

Table 2.3.1. Hourly Traffic Volumes, Monday, May 30, 1994

Time (PM)	Volume
11:00-12:00	1,105
12:00-1:00	1,229
1:00-2:00	1,427
2:00-3:00	1,441
3:00-4:00	1,408
4:00-5:00	1,330
5:00-6:00	1,176
6:00-7:00	1,087

From Table 2.3.1, the highest hourly traffic volume occurs between 2:00 and 3:00 PM when 1,441 vehicles were counted. The vehicle classification data collected from 2:00 to 3:00 PM is used to determine the design hour vehicle classification percentages, which are shown in Section 3.5.

3. DESIGN HOUR TRAFFIC VOLUMES

It is standard transportation engineering practice to design facilities that can accommodate the traffic volumes anticipated 20 years after design/construction of the facility. This standard makes good sense for most transportation facilities, since it is usually more expensive and more environmentally harmful to frequently rebuild a facility that was not adequately designed to accommodate traffic for 20 years or more. This standard is especially appropriate for U.S. 189 through Provo Canyon, and as a result, 20 years will be used as the design horizon. With the 20 year design horizon in mind, and considering that final construction plans for the roadway will not be completed until at least 1995, the design year is considered to be 2015.

The actual analysis used to determine if a roadway is adequately designed typically uses the volumes from a select one hour period as input. The actual hour chosen is usually selected from among the 100 highest hourly volumes expected in the design year. The remainder of this section will be used to determine the design hour volume in the year 2015. The methods and assumptions used throughout this section will be explained as completely as possible.

3.1. 100 Highest Hourly Volumes

As stated previously, it is standard practice when planning for a highway design to choose an hourly traffic volume from among the 100 highest hours expected in the design year. This volume is then used as an input for determining the capacity of the roadway in the design year. Designing for the highest hour of the year would result in an over-design for all other hours of the year. While designing for an hourly volume less than the 100 highest of the year would result in an under-designed facility for virtually all of the peak hours of the year. In the case of U.S. 189 through Provo Canyon, this could mean gridlock at the beginning and end of each summer weekend. From among the 100 highest hours, the 30th or 50th highest hour is usually chosen as the design hour. For this study, the specific hour will be chosen based on an analysis of the historical traffic count data provided by UDOT. From that data, the 100 highest hourly volumes have been determined and ranked for 1990 through 1993. Table 3.1.1 shows the 100 highest hourly volumes and the volumes as a percentage of annual average daily traffic (AADT) for each year.

Table 3.1.1. 100 Highest Hourly Volumes and Volumes as a Percentage of AADT, 1990 - 1993

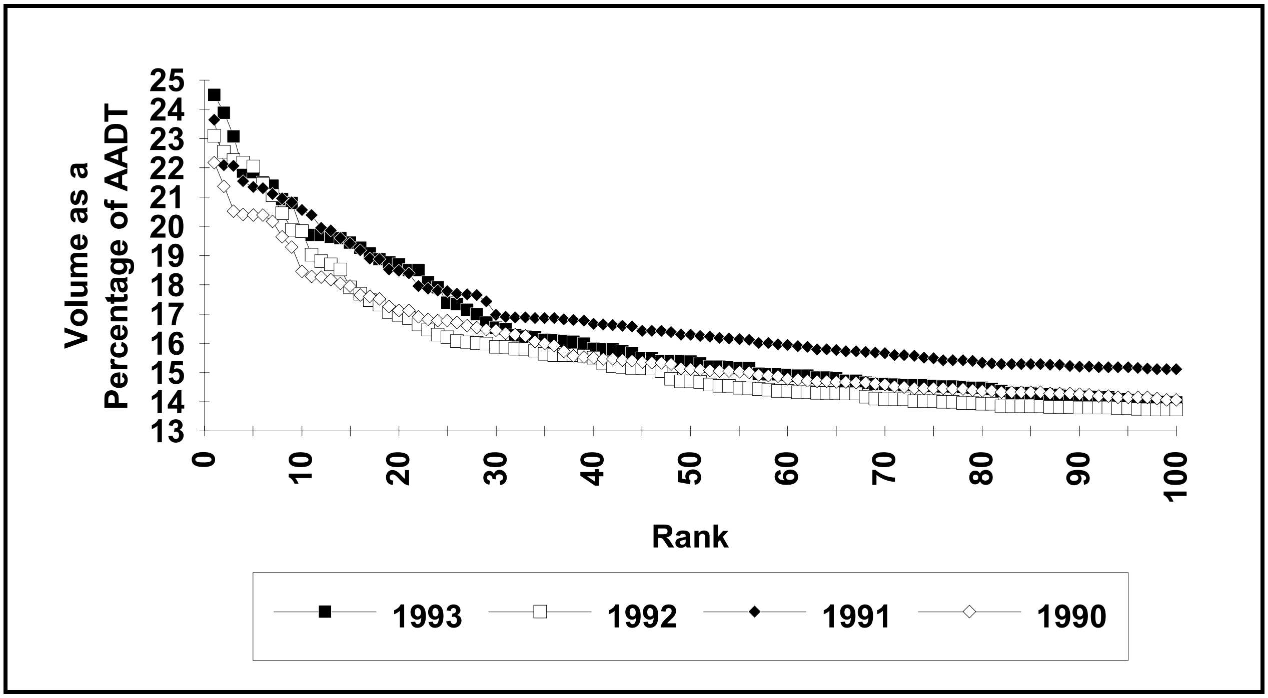
	1993		1992		1991		1990		4-Year Average
Rank	Volume	% AADT	Volume	% AADT	Volume	% AADT	Volume	% AADT	% AADT
1	2002	24.5%	1794	23.1%	1699	23.6%	1541	22.2%	23.3%
2	1952	23.9%	1752	22.5%	1588	22.1%	1484	21.4%	22.5%
3	1886	23.1%	1730	22.3%	1586	22.1%	1426	20.5%	22.0%
4	1787	21.9%	1724	22.2%	1548	21.5%	1417	20.4%	21.5%
5	1785	21.8%	1714	22.1%	1534	21.3%	1416	20.4%	21.4%
6	1758	21.5%	1667	21.4%	1531	21.3%	1416	20.4%	21.2%
7	1749	21.4%	1637	21.1%	1517	21.1%	1401	20.2%	20.9%
8	1710	20.9%	1589	20.4%	1506	21.0%	1364	19.6%	20.5%
9	1699	20.8%	1546	19.9%	1496	20.8%	1340	19.3%	20.2%
10	1620	19.8%	1542	19.8%	1478	20.6%	1282	18.5%	19.7%
11	1611	19.7%	1479	19.0%	1465	20.4%	1270	18.3%	19.4%
12	1611	19.7%	1462	18.8%	1434	19.9%	1269	18.3%	19.2%
13	1606	19.7%	1453	18.7%	1427	19.9%	1263	18.2%	19.1%
14	1602	19.6%	1440	18.5%	1409	19.6%	1254	18.1%	18.9%
15	1590	19.5%	1392	17.9%	1396	19.4%	1247	18.0%	18.7%
16	1574	19.3%	1375	17.7%	1379	19.2%	1227	17.7%	18.4%
17	1559	19.1%	1359	17.5%	1359	18.9%	1223	17.6%	18.3%
18	1542	18.9%	1346	17.3%	1357	18.9%	1217	17.5%	18.1%
19	1533	18.8%	1326	17.1%	1331	18.5%	1199	17.3%	17.9%
20	1529	18.7%	1320	17.0%	1328	18.5%	1190	17.1%	17.8%
21	1513	18.5%	1311	16.9%	1323	18.4%	1190	17.1%	17.7%
22	1512	18.5%	1293	16.6%	1290	17.9%	1175	16.9%	17.5%
23	1479	18.1%	1281	16.5%	1284	17.9%	1168	16.8%	17.3%
24	1464	17.9%	1267	16.3%	1280	17.8%	1166	16.8%	17.2%
25	1421	17.4%	1259	16.2%	1279	17.8%	1165	16.8%	17.0%
26	1418	17.3%	1250	16.1%	1272	17.7%	1161	16.7%	17.0%
27	1401	17.1%	1247	16.0%	1270	17.7%	1154	16.6%	16.9%
28	1390	17.0%	1244	16.0%	1269	17.7%	1148	16.5%	16.8%
29	1366	16.7%	1242	16.0%	1253	17.4%	1144	16.5%	16.6%
30	1352	16.5%	1234	15.9%	1220	17.0%	1143	16.5%	16.5%
31	1348	16.5%	1234	15.9%	1215	16.9%	1135	16.3%	16.4%
32	1331	16.3%	1229	15.8%	1214	16.9%	1132	16.3%	16.3%
33	1326	16.2%	1227	15.8%	1214	16.9%	1129	16.3%	16.3%
34	1325	16.2%	1224	15.7%	1213	16.9%	1116	16.1%	16.2%
35	1318	16.1%	1216	15.6%	1213	16.9%	1111	16.0%	16.2%
36	1315	16.1%	1213	15.6%	1212	16.9%	1107	15.9%	16.1%
37	1314	16.1%	1213	15.6%	1209	16.8%	1093	15.7%	16.1%
38	1312	16.1%	1213	15.6%	1207	16.8%	1082	15.6%	16.0%
39	1306	16.0%	1210	15.6%	1206	16.8%	1079	15.5%	16.0%
40	1293	15.8%	1206	15.5%	1198	16.7%	1078	15.5%	15.9%
41	1291	15.8%	1190	15.3%	1196	16.6%	1075	15.5%	15.8%
42	1291	15.8%	1184	15.2%	1195	16.6%	1075	15.5%	15.8%
43	1285	15.7%	1180	15.2%	1194	16.6%	1071	15.4%	15.7%
44	1280	15.7%	1179	15.2%	1192	16.6%	1070	15.4%	15.7%
45	1265	15.5%	1178	15.2%	1181	16.4%	1067	15.4%	15.6%
46	1265	15.5%	1176	15.1%	1180	16.4%	1066	15.3%	15.6%
47	1259	15.4%	1169	15.0%	1180	16.4%	1066	15.3%	15.6%
48	1259	15.4%	1150	14.8%	1178	16.4%	1063	15.3%	15.5%
49	1259	15.4%	1143	14.7%	1172	16.3%	1052	15.1%	15.4%
50	1257	15.4%	1142	14.7%	1171	16.3%	1050	15.1%	15.4%

Table 3.1.1. (cont.) 100 Highest Hourly Volumes and Volumes as a Percentage of AADT, 1990 - 1993

	1993		1992		1991		1990		4-Year Average
Rank	Volume	% AADT	Volume	% AADT	Volume	% AADT	Volume	% AADT	% AADT
51	1251	15.3%	1141	14.7%	1169	16.3%	1049	15.1%	15.3%
52	1243	15.2%	1134	14.6%	1167	16.2%	1048	15.1%	15.3%
53	1243	15.2%	1130	14.5%	1164	16.2%	1046	15.1%	15.2%
54	1241	15.2%	1130	14.5%	1162	16.2%	1045	15.0%	15.2%
55	1240	15.2%	1125	14.5%	1161	16.2%	1044	15.0%	15.2%
56	1239	15.2%	1124	14.5%	1159	16.1%	1043	15.0%	15.2%
57	1223	15.0%	1122	14.4%	1151	16.0%	1037	14.9%	15.1%
58	1222	15.0%	1120	14.4%	1151	16.0%	1035	14.9%	15.1%
59	1221	14.9%	1117	14.4%	1148	16.0%	1034	14.9%	15.0%
60	1219	14.9%	1117	14.4%	1146	15.9%	1027	14.8%	15.0%
61	1217	14.9%	1114	14.3%	1143	15.9%	1026	14.8%	15.0%
62	1217	14.9%	1114	14.3%	1141	15.9%	1023	14.7%	15.0%
63	1213	14.8%	1113	14.3%	1136	15.8%	1022	14.7%	14.9%
64	1213	14.8%	1112	14.3%	1135	15.8%	1021	14.7%	14.9%
65	1211	14.8%	1112	14.3%	1134	15.8%	1020	14.7%	14.9%
66	1204	14.7%	1111	14.3%	1131	15.7%	1019	14.7%	14.9%
67	1203	14.7%	1110	14.3%	1130	15.7%	1018	14.7%	14.8%
68	1198	14.7%	1101	14.2%	1129	15.7%	1018	14.7%	14.8%
69	1194	14.6%	1097	14.1%	1127	15.7%	1016	14.6%	14.8%
70	1194	14.6%	1096	14.1%	1126	15.7%	1013	14.6%	14.7%
71	1192	14.6%	1096	14.1%	1122	15.6%	1009	14.5%	14.7%
72	1191	14.6%	1095	14.1%	1121	15.6%	1008	14.5%	14.7%
73	1191	14.6%	1090	14.0%	1120	15.6%	1005	14.5%	14.7%
74	1191	14.6%	1089	14.0%	1115	15.5%	1005	14.5%	14.6%
75	1189	14.5%	1089	14.0%	1114	15.5%	1005	14.5%	14.6%
76	1188	14.5%	1088	14.0%	1109	15.4%	1004	14.5%	14.6%
77	1187	14.5%	1088	14.0%	1109	15.4%	1003	14.4%	14.6%
78	1186	14.5%	1084	13.9%	1108	15.4%	1003	14.4%	14.6%
79	1184	14.5%	1084	13.9%	1107	15.4%	1000	14.4%	14.6%
80	1183	14.5%	1083	13.9%	1103	15.3%	999	14.4%	14.5%
81	1180	14.4%	1083	13.9%	1101	15.3%	998	14.4%	14.5%
82	1174	14.4%	1077	13.9%	1100	15.3%	996	14.3%	14.5%
83	1170	14.3%	1077	13.9%	1100	15.3%	996	14.3%	14.5%
84	1170	14.3%	1077	13.9%	1100	15.3%	995	14.3%	14.4%
85	1170	14.3%	1076	13.8%	1099	15.3%	995	14.3%	14.4%
86	1165	14.3%	1076	13.8%	1099	15.3%	995	14.3%	14.4%
87	1165	14.3%	1074	13.8%	1098	15.3%	993	14.3%	14.4%
88	1163	14.2%	1074	13.8%	1097	15.3%	993	14.3%	14.4%
89	1160	14.2%	1074	13.8%	1095	15.2%	993	14.3%	14.4%
90	1159	14.2%	1073	13.8%	1093	15.2%	991	14.3%	14.4%
91	1158	14.2%	1073	13.8%	1093	15.2%	990	14.3%	14.4%
92	1157	14.2%	1072	13.8%	1092	15.2%	987	14.2%	14.3%
93	1156	14.1%	1072	13.8%	1091	15.2%	986	14.2%	14.3%
94	1151	14.1%	1071	13.8%	1091	15.2%	984	14.2%	14.3%
95	1151	14.1%	1071	13.8%	1091	15.2%	984	14.2%	14.3%
96	1149	14.1%	1070	13.8%	1089	15.2%	983	14.1%	14.3%
97	1147	14.0%	1068	13.7%	1088	15.1%	983	14.1%	14.3%
98	1146	14.0%	1068	13.7%	1087	15.1%	980	14.1%	14.2%
99	1144	14.0%	1067	13.7%	1087	15.1%	978	14.1%	14.2%
100	1143	14.0%	1067	13.7%	1086	15.1%	977	14.1%	14.2%

For each year, the volume and the volume as a percentage of annual average daily traffic (AADT) decreases rapidly down to approximately the 30th highest hour. After the 30th highest hour, the rate of decrease in the hourly volumes is fairly flat, which shows the relatively small difference between them. Figure 3.1.1 shows a plot of the hourly volumes as a percentage of AADT for 1990 through 1993.

Figure 3.1.1. Plot of 100 Highest Hourly Volumes as a Percentage of AADT, 1990 -1993



The plots show that the rate of decrease begins to lessen at the 30th highest hour, however, the rate of decrease is almost constant from the 50th to 100th highest hour. This is evident in Table 3.1.1, where the four year average volume as a percentage of AADT is 15.4% for the 50th highest hour and 14.2% for the 100th highest hour. This represents a change of only 1.2% between the 50th and 100th highest hour. This indicates that the 50th highest hourly volume closely represents the 50th through 100th highest hours. For this study the 50th highest hourly volume will be used as the design hour volume. The four-year average for the 50th highest hour of 15.4% of AADT will be applied to the design year volume to determine the actual design hour volume.

3.2. Design Year Annual Average Daily Traffic Volume

To determine the actual design hour volume, a projection for the design year (2015) annual average daily traffic (AADT) was made. The historical traffic count data supplied by UDOT was utilized for this purpose. The data is shown in Table 2.1.1 and again in Table 3.2.1.

Table 3.2.1. Average Annual Daily Traffic, 1975 - 1993

Year	Annual Average Daily Traffic	Year	Annual Average Daily Traffic
1975	4290	1985	5660
1976	4610	1986	5780
1977	4690	1987	6150
1978	5370	1988	6480
1979	5170	1989	6642
1980	5150	1990	6947
1981	5410	1991	7188
1982	5580	1992	7772
1983	5770	1993	8173
1984	5710		

The change in AADT for each year from 1975 to 1993 was used to develop a projection equation for the design year AADT as follows:

Historical Traffic-Based AADT Projection Equation

179.616 x (Design Year) - 350,434 = Design Year AADT

Regression analysis was used to develop both the equation and the statistics that indicate the significance of the equation. The principal measure of the significance of the projection equation is the statistical value R-Square, which provides a measure of how well the equation describes the change in AADT in terms of the independent variable, in this case, the year. The R-Square for this equation is 0.92, which means that 92% of the historical increase in traffic volumes can be explained by the change in years. If traffic growth in the canyon continues to increase at rates similar to the last 18 years, the historical traffic-based equation will describe approximately 92% of that growth.

An additional projection equation was developed using historical population data provided by the Utah Office of Planning and Budget for the Mountainlands Multi-County District (MCD). Mountainlands MCD includes Utah, Wasatch and Summit Counties. U.S. 189 through Provo Canyon crosses through both Utah and Wasatch Counties. Summit County is located a short distance to the north of the project area. For this study, all three counties are assumed to heavily influence traffic volumes on U.S. 189 through the project area. Table 3.2.2 shows the population of the Mountainlands Multi-County District for 1975 through 1993.

Table 3.2.2. Mountainlands Multi-County District Population, 1975 - 1993

Year	Population	Year	Population
1975	191,300	1985	267,200
1976	199,750	1986	269,850
1977	209,700	1987	275,900
1978	219,900	1988	279,050
1979	229,000	1989	283,100
1980	239,400	1990	291,856
1981	246,950	1991	299,291
1982	252,300	1992	303,891
1983	258,300	1993	309,137
1984	265,000		

The changes in Mountainlands MCD population and AADT for each year from 1975 to 1993 were used to develop a projection equation for the design year AADT as follows:

Population-Based AADT Projection Equation

0.02815 x (Design Year Population, Mountainlands MCD) - 1,322 = Design Year AADT

Regression analysis was used to develop both the equation and the statistics that indicate the significance of the equation. As stated previously, the principal measure of the significance of the projection equation is the statistical value R-Square, which provides a measure of how well the equation describes the change in AADT in terms of the independent variable. In this case the independent variable is the population of the Mountainlands MCD. The R-Square for this equation is 0.88, which means that 88% of the historical increase in traffic volumes in the canyon can be explained by the change in the population of the Mountainlands MCD. If the population of the Mountainlands MCD continues to increase at rates similar to the last 18 years, the population-based equation will describe approximately 88% of the growth in traffic volumes during the same period.

Using 2015 as the design year, the historical traffic-based projection equation is used to project the design year annual average daily traffic (AADT) as follows:

Historical Traffic-Based AADT Projection

179.616 x (2015) - 350,434 = <u>11,491 AADT</u>

The Utah Office of Planning and Budget's projection for the population of the Mountainlands Multi-County District for 2015 is 432,936. Using the population-based AADT projection equation with the 2015 population of 432,936 as input, the design year AADT is calculated as follows:

Population-Based AADT Projection

0.02815 x (432,936) - 1,322 = <u>10,863 AADT</u>

3.3. Design Hour Volume

The historical traffic-based and population-based AADT projections are used to calculate two alternative values for the design hour volume. As stated previously, the 50th highest hourly volume will be used as the design hour volume. The four-year average for the 50th highest hour of 15.4% of AADT will be applied to the design year volumes (AADT) to determine the two alternatives for design hour volume. The historical traffic-based design year projection of 11,491 AADT is used to calculate the design hour volume as follows:

Historical Traffic-Based Design Hour Volume Projection

11,491 AADT x 15.4% = <u>1,770 Vehicles Per Hour</u>

The Population-Based design year projection of 10,863 AADT is used to calculate an alternative design hour volume as follows:

Population-Based Design Hour Volume Projection

10,863 AADT x 15.4% = <u>1,673 Vehicles Per Hour</u>

From the two alternatives for design hour volume, the lower value of 1,673 vehicles per hour (VPH) will be used to determine the requirements for improvement to U.S. 189 through Provo Canyon from Wildwood to Deer Creek State Park. The design hour volume of 1,673 VPH is used in Section 4, Capacity Analysis, to determine the operational level of service expected for each alternative in the design year.

3.4. Design Hour Directional Distribution

When designing highway segments such as U.S. 189 through Provo Canyon, it is standard engineering practice to perform the capacity analysis with the assumptions that some amount greater than 50% of the design hour traffic volume will be traveling in one direction and that some amount less than 50% will be traveling in the opposite direction. The total will always equal 100% of the design hour traffic volume. On a highway such as U.S. 189 through Provo Canyon, directional distribution or split helps account for periods where more vehicles may be traveling north for the evening commute to Wasatch or Summit Counties from the Provo/Orem area. Directional distribution also accounts for periods where more vehicles may be returning to the Provo/Orem area from a weekend trip to Deer Creek State Park or other recreation areas north and east of Provo Canyon.

Although there is only a small difference in volume from one of the 100 highest hourly volumes to the next, the directional distribution fluctuates significantly from hour to hour among the 100 highest hours. Consequently, the directional distribution for a single hour, such as the 50th highest hour, is not reliable for use in the capacity analysis. Instead, the 40th to 60th highest hours were analyzed and averaged for directional distribution. The permanent count station data supplied by UDOT includes directional distributions for the 40th to 60th highest hours of 1993. Table 3.4.1 shows a summary of the directional distribution data.

Table 3.4.1. Directional Distribution Data, 40th to 60th Highest Hours, 1993

	Hourly Volume					Direction
Rank	NB	SB	Both Directions	NB %	SB %	Favored
40	285	1008	1293	22%	78%	SB-Anomoly
41	596	695	1291	46%	54%	SB
42	604	687	1291	47%	53%	SB
43	631	654	1285	49%	51%	SB
44	584	696	1280	46%	54%	SB
45	629	636	1265	50%	50%	Even
46	596	669	1265	47%	53%	SB
47	391	868	1259	31%	69%	SB-Anomoly
48	630	629	1259	50%	50%	Even
49	633	626	1259	50%	50%	Even
50	473	784	1257	38%	62%	SB
51	594	657	1251	47%	53%	SB
52	726	517	1243	58%	42%	NB
53	486	757	1243	39%	61%	SB
54	631	610	1241	51%	49%	NB
55	536	704	1240	43%	57%	SB
56	582	657	1239	47%	53%	SB
57	574	649	1223	47%	53%	SB
58	591	631	1222	48%	52%	SB
59	697	524	1221	57%	43%	NB
60	551	668	1219	45%	55%	SB

Table 3.4.1 shows whether the directional distribution favored the northbound or southbound direction of travel, or if the split was even. The 40th and 47th highest hours have directional distributions well outside the average for the 40th to 60th highest hours. In Table 3.4.2 the hours favoring the southbound direction of travel are averaged. In Table 3.4.3 the hours favoring the northbound direction of travel are averaged. The hours with distributions well outside the average (anomalies) are left out of the tables.

Table 3.4.2. Average Directional Distribution Favoring Southbound Travel

	Hourly Volume					Direction
Rank	NB	SB	Both Directions	NB %	SB %	Favored
41	596	695	1291	46%	54%	SB
42	604	687	1291	47%	53%	SB
43	631	654	1285	49%	51%	SB
44	584	696	1280	46%	54%	SB
46	596	669	1265	47%	53%	SB
50	473	784	1257	38%	62%	SB
51	594	657	1251	47%	53%	SB
53	486	757	1243	39%	61%	SB
55	536	704	1240	43%	57%	SB
56	582	657	1239	47%	53%	SB
57	574	649	1223	47%	53%	SB
58	591	631	1222	48%	52%	SB
60	551	668	1219	45%	55%	SB
			Average	45%	55%	SB

Table 3.4.3. Average Directional Distribution Favoring Northbound Travel

	Hourly Volume					Direction
Rank	NB	SB	Both Directions	NB %	SB %	Favored
52	726	517	1243	58%	42%	NB
54	631	610	1241	51%	49%	NB
59	697	524	1221	57%	43%	NB
			Average	55%	45%	NB

Table 3.4.2 and 3.4.3 show that the directional distribution for an hour in the range of the 40th to 60th highest hours probably will have directional distributions of 45% northbound/55% southbound, or 55% northbound/45% southbound. Each of these two directional distributions is applied to the design hour volume when performing the capacity analysis for this study.

3.5. Design Hour Vehicle Classification

The traffic volume and classification data collected by Centennial are used to determine the design hour vehicle classification. As stated in Section 2.3, counts were collected from 11:00 AM to 7:00 PM on Monday, May 30, 1994, on U.S. 189 just north of the Wildwood/Sundance turnoff. From those counts, the peak hour was found to be from 2:00 to 3:00 PM, when the hourly volume was 1,441 vehicles. The vehicle classification data collected from 2:00 to 3:00 PM is used to determine the design hour vehicle classification percentages, which are as follows:

Northbound

96.4% Passenger Cars	0.0% Buses
3.4% Recreational Vehicles	0.2% Trucks

Southbound

82.8% Passenger Cars	0.0% Buses
15.5% Recreational Vehicles	1.8% Trucks

The counts show a greater percentage of the heavy vehicle traffic to be traveling south. As stated previously, the counts were collected on the Monday following Memorial Day weekend. For this study, it is assumed that the northbound and southbound percentages of heavy vehicles of each classification will be reversed at the beginning of a weekend. This accounts for periods where more heavy vehicles are traveling north than south, such as a Friday evening. The design hour vehicle classification percentages are applied to the design hour volume when performing the capacity analysis for this study.

4. CAPACITY ANALYSIS

Capacity, or roadway performance, is defined as the maximum hourly rate at which persons or vehicles can reasonably be expected to pass a point or traverse a uniform section of roadway during a given time period. Capacity analysis takes into account factors such as prevailing roadway width and grade and traffic. Capacity analysis estimates the maximum amount of traffic that can be accommodated by a given facility while maintaining operational qualities, level of service, as defined in nationally recognized standards developed by the Transportation Research Board.

Level of service for roadways is a qualitative measure describing operational conditions within a traffic stream and their perception by motorists and/or pedestrians. A level of service definition generally describes these conditions in terms of such factors as travel time, freedom to maneuver, traffic interruptions, and comfort and convenience, all of which affect safety. There are six levels of service describing these conditions, ranging from A to F, which have been standardized by the Transportation Research Board. Level of Service A represents a free-flowing traffic condition where motorists are affected very little by other motorists, there is a high degree of freedom to select desired speeds, and the level of comfort, convenience, and safety to the motorist is excellent. Level of Service B, the lower level of which is often used for the design of rural highways, is the zone of stable flow with some slight restriction of driver freedom. With Level of Service C, driver freedom is further constrained. Level of Service D reflects little freedom for driver maneuverability, and while operating speeds are still tolerable, the condition of unstable flow is being approached. Low operating speed, volumes at or near capacity, and a reduced level of safety occur in Level of Service E. Level of Service F is characterized by congested flow conditions with stoppages as the amount of traffic approaching a point exceeds the amount that can pass that point. Motorists have little if any freedom to choose speeds or lanes of travel, and experience discomfort, inconvenience, delay, and a further decreased level of safety.

The analysis was performed using the procedures outlined in the 1985 Highway Capacity Manual, developed by the Transportation Research Board and the latest version of the Highway Capacity Software.

The analysis was performed on each of the alignment alternatives described in Section 1, using the design hour traffic volume, directional distribution, and classification percentages determined in Section 3. Table 4.1 shows a summary of the level of service analysis for each alternative.

Table 4.1. Design Year Level of Service Summary

Alternative	Level of Service Northbound	Level of Service Southbound
1. Existing Alignment	F	F
2. Two Lanes Northbound/ One Lane Southbound	B	E
3. One Lane Northbound/ Two Lanes Southbound	F	A
4. Two Lanes Each Direction SEIS Preferred Alignment	B	A

5. FINDINGS AND RECOMMENDATIONS

Throughout this study, design values were chosen that favor fewer improvements to U.S. 189 from Wildwood to Deer Creek State Park. The 100 highest hourly volumes plotted in Figure 3.1.1 show that the rate of decrease in hourly volumes lessens at the 30th highest hour. However, the lower, 50th highest hour, was chosen as the design hour. Two separate equations were developed to project design year volumes. Of the two, the population-based projection equation was used for projection purposes, which resulted in a lower design year volume. The directional distribution data showed some extreme directional splits that were not included in the values averaged to determine the design hour directional distribution. In each case, the lower value slightly favors an alignment alternative with fewer improvements and that is potentially less expensive than the alignment alternative required for the higher design hour volume.

The existing alignment is estimated to operate at Level of Service F in the design year, 2015. Constructing a facility with two lanes in the northbound direction and one in the southbound direction results in Level of Service B on the northbound lanes and Level of Service E on the southbound lane. Constructing a facility with one lane in the northbound direction and two in the southbound direction results in Level of Service F on the northbound lane and Level of Service A on the southbound lanes. Each of these alternatives would operate at an unacceptable level of service in the design year, resulting in decreased traffic safety.

The SEIS Preferred Alignment with two lanes in each direction of travel, results in Level of Service B on the northbound lanes, and Level of Service A on the southbound lanes. Considering design year traffic volumes, capacity, and traffic safety, it is our recommendation that the facility be designed and constructed with two lanes in each direction.